



NASA STTR 2012 Phase I Solicitation

T8.03 Science Instruments for Small Missions (SISM)

Lead Center: ARC

Advancements in supporting spacecraft technologies are making small spacecraft more and more capable. Features such as extensive computing power, attitude determination and control systems, and even propulsion are allowing mission designers to consider small and very small spacecraft to perform operational and scientific investigations. However, one area that is lagging is the miniaturization of instrument systems that would be compatible with this new class of small spacecraft. Until science instruments can be downsized in order for them to be accommodated on small spacecraft, the utility of cubesats, nanosats, and mini-spacecraft platforms will be limited.

To stimulate and create scientific instrument technologies that are compatible with small spacecraft, this subtopic seeks to identify, develop, and prepare for flight demonstration, scientific instruments compatible with one or more of the small spacecraft platforms described at the end of this solicitation. Science applications may be in Astrophysics, Earth Science, Heliophysics, Planetary Science, or Astrobiology.

Examples for proposals sought include, but are not limited to:

Astrophysics:

- *Need* - Ability to view diffuse / dispersed / low-intensity astrophysical phenomena requiring zero light background without high spatial resolution; good for full-sky mapping applications.
- *Instrument* - Multiband / hyperspectral imaging compact telescope
- *Measurement* - ERE emission from bright ionized (HII) regions, e.g., Orion Bar ionization edge, and correlation of ERE and PAH emissions from any orbit with at least multi-month lifetime.
- *Impact* - Understanding of astrophysical phenomena, esp. those relevant to carbon sources. Such measurement will demonstrate the science capability on small spacecraft.

Earth Science:

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- *Need* - Mapping terrestrial phenomena with multiple low-cost imagers for short-revisit period capability.
 - *Instrument* - Hyperspectral Earth imager (including constellations of multiple imagers)
 - *Measurement* - Ocean color due to algal blooms and other natural phenomena, or anthropogenic impact due to deforestation, CO₂ emissions, etc. Such measurements may require spectral mapping of large areas with short re-map period. Demonstration may be from a sun synchronous low earth orbit.
 - *Impact* - Better tracking / understanding of algal blooms sources, CO₂ sources, etc. Such measurement will demonstrate science capability on small spacecraft.

Earth Science:

- *Need* - Long-path atmospheric analysis (using sun as light source)
- *Instrument* - Compact (FT)IR spectrometer w/ telescope
- *Measurement* - Assess highly dilute inorganics or organics in upper atmosphere due to pollution or meteoritic infall, from Low Earth Orbit.
- *Impact* - Improved understanding of pollutant dynamic mobility/ degradation and/or cosmic organic sources. Such measurement will demonstrate science capability on small spacecraft.

Planetary Science:

- *Need* -
 - Evaluating the reactivity / habitability of extraterrestrial surfaces.
 - On orbit analysis of materials exposed to the space environment.
- *Instrument* - Compact XPS (X-ray photoelectron spectrometer) for surface chemistry analysis - moon, Mars, NEOs, beyond.
- *Measurement* - Characterization of regolith chemical reactivity: quantify reactive inorganic ions & radicals incl. oxyhalides, peroxides, superoxides, odd-O/odd-H species; regolith organic alteration products. Subsurface measurement of supports for and threats to life: energy sources; possible toxic & reactive compounds; soluble anions/cations& dissolved gases.
- *Impact* - Buy down of long term risk. Demonstrating on-orbit material analysis capability, for technology that will be deployed on landers or rovers, will lead to better understanding of surface conditions that impact survival of organics, biomarkers, and life.

Planetary Science:

- *Need* -
 - Investigating the Reactivity / habitability / evolution of extraterrestrial surfaces.

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- On orbit analysis of materials exposed to the space environment.
 - *Instrument* - Compact SIMS (secondary ion mass spectrometer) or LDMS (laser desorption mass spec) for surface mass & chemistry analysis - moon, Mars, NEOs, beyond.
 - *Measurement* - Characterization of regolith chemical reactivity: quantify reactive inorganic ions & radicals incl. oxyhalides, peroxides, superoxides, odd-O/odd-H species; regolith organic alteration products. Subsurface measurement of supports for and threats to life: energy sources; possible toxic & reactive compounds; soluble anions/cations& dissolved gases.
 - *Impact* - Buy down of long term risk. Demonstrating on-orbit material analysis capability, for technology that will be deployed on landers or rovers, will lead to better understanding of surface conditions that impact survival of organics, biomarkers, and life.

Astrobiology:

- *Need* - Evaluate rates and nature of mutations caused by the space environment.
- *Instrument* - Miniaturized DNA sequencer to study mutations
- *Measurement* - Cultures of cells or small organisms supported in space radiation environment for months: evaluate genetic profile after 1000's of generations Location would be High Earth Orbit, geo-syn, or various libration points.
- *Impact* - Understand how mutation can play a role in rapid evolution in response to radiation stressors. Miniaturization and demonstration on a small spacecraft mission may eventually lead to a compact sequencer for personalized medicine.

Proposals are sought that significantly advance state of the art for scientific measurements. Proposals for science instruments that represent only incremental improvements in the state-of-the-art capabilities, or are of interest to relatively few users are not appropriate for this solicitation. Proposed concepts should show a relevance to external customers or stakeholders needs.

Proposer shall describe the proposed design, development, analysis, testing and evaluation needed for the technology; and outline a concept of operations for demonstration of the technology on a small mission platform. How the proposed technology is differentiated from currently available technologies must be clearly communicated.

Phase I contracts will be expected to demonstrate feasibility, and Phase II contracts will be expected to fabricate and complete ground testing on an actual instrument/test article for potential demonstration on a small mission.

Small Spacecraft Platforms

Cubesats - Cubesats are usually 10 x 10 x 10 cm (for a 1U) or 10 x 10 x 30 cm (for a 3U) nanosatellites. Other sizes are also in development, such as a 6U. Cubesats are typically launched as auxiliary spacecraft. Multiple cubesats may also be launched simultaneously in order to create constellations and other useful space architectures.

Specifications and standards for cubesats may be found at (<http://www.cubesat.org/>).

University Nanosats - University Nanosats are typically 50 x 50 x 60 cm and weigh less than 50 kg. They are also auxiliary spacecraft launched with other spacecraft on rideshare missions, typically using 15" or 8" Lightband deployment systems (see <http://www.planetarysystemscorp.com/> for more info on Lightband and Planetary Systems, Corp.).

The Air Force Research Lab has sponsored the development of these spacecraft via the University Nanosat Program (see <http://prs.afrl.kirtland.af.mil/UNP/>).

Technology Demonstration Spacecraft - A larger spacecraft platform for the demonstration of a number of instrument payloads was illustrated by the recent NASA/MSFC FASTSAT mission. FASTSAT is an ESPA-class spacecraft, deployed via a 15" Lightbanddeployer, and is designed to accommodate a number of independent instrument systems. FASTSAT provides basic power, data/communications, and thermal management support for these payloads as part of an integrated space flight demonstration mission.